Rating physical working capacity based on respiratory function

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Abstract

Objective of the study was to identify approaches to rating physical working capacity based on the respiratory function.

Results and conclusion. For sports pedagogy, the subject of which is movements, it is advisable to distinguish from a large number of factors and responses that determine the physical working capacity level an indicator that would integrate multi-level responses. This indicator is energy supply: aerobic (ox-idation) and anaerobic (primarily anaerobic glycolysis). It is the relationship between these two processes that determines the level of physical working capacity.

Numerous tests (since 2003) of people of different ages and physical fitness levels (from beginners to Olympic champions) have proved that the dynamics of the mentioned ventilatory capacity and ventilatory pulse indicators reflect the level of physical working capacity by demonstrating:

– the presence or absence of neuromuscular fatigue;

– aerobic or anaerobic type of energy supply in terms of load increment.

The accessibility of the proposed approaches to physical fitness tests provides ample opportunities for monitoring and managing recreational and sports activities.

Keywords: *tests, physical fitness, problems, power, respiration, pulse.*

Background. The success of physical education and sports activities is largely determined by the effectiveness of monitoring of the human response to physical loads. Modern technologies provide great opportunities for measuring different determinants of motor activity [1, 7, 13]. However, «what is true of a group member is not true of the group as a whole». It should also be noted that sophisticated monitoring technologies are not available to everyone.

At the same time, monitoring is a must for everyone – children, adults, beginners, and champi-ons. It is impossible to set clear, unambiguous priorities. The increasing need for objective monitoring of physical loads has revealed many problems, including:

• The number of those involved in health-improving physical practices, fitness, and children's and youth sports is much greater than that of highly skilled athletes, with different means for monitoring.

• By no means do all coaches recognize the importance of regular monitoring.

• By no means do all experts fully understand what needs to be monitored.

• Monitoring techniques for a narrow range of qualified athletes require sophisticated equipment and services from trained professionals, which are not always readily available or feasible.

• In sports clubs and sports schools, even with a sports doctor or a doctor's office, it is not ad-visable to maintain expensive equipment and implement complex methods.

As a result, a significant number of athletes perform physical loads uncontrolled, which leads to inefficient recreational and sports activities. There is a need for physical fitness monitoring procedures accessible to a wide range of trainees.

Objective of the study was to identify approaches to rating physical working capacity based on the respiratory function.

Results and discussion. For sports pedagogy, the subject of which is movements, it is advisable to distinguish from a large number of factors and responses that determine the physical working capacity level an indicator that would integrate multi-level responses. This indicator is energy supply: aerobic (ox-idation) and anaerobic (primarily anaerobic glycolysis) [8]. It is the relationship between these two pro-cesses that determines the level of physical working capacity [10].

Historically, the predominance of the type of energy supply has been identified through the gas analysis of the exhaled air or through the measurement of the lactate concentration in the bloodstream, which is relatively expensive and not always agreeable, for example, in children's sports. However, in-creased anaerobic glycolysis can be due to the activation of the respiratory function [11]. Modern spiro-graphs make it possible to quickly measure respiratory minute volume (RMV, l/min). The respiratory sys-tem reacts immediately to any physical load. All that is left to do is to compare the respiratory minute volume rate to the amount of workload performed.

In this comparison, it becomes possible to formalize physical loads in cyclic locomotions in terms of power or its equivalents, such as speed and tempo. However, it is quite difficult to do in other motor actions, such as sports games or martial arts.

It should be emphasized that with an increase in heart rate to an average value of 170 bpm, work power (N, W, Fig. 1) increases linearly [11].

In addition, according to our records, in a wide range of movements, heart rate highly correlates with the increasing indicators characterizing load power or its equivalents (r=0.85-0.98). This makes it possible to take as an argument not only the power mechanical characteristics (equivalents) but also heart rate, which helps estimate physical working capacity based on the energy supply type (aerobic, anaerobic) outside laboratory conditions, for example, during trainings.

The function is the non-linear dependence of respiratory minute volume on power (including its equivalents) and heart rate under loading (Fig. 1) [2]. Among the identified functions are [3, 4, 5]:

1. Ventilatory capacity (VC, l/W, or specific respiratory volume), the first derivative of dRMV/dN, physical significance – the volume of ventilated air necessary to provide a unit of work.

2. Ventilatory pulse (VP, l/beat), the first derivative of dRMV/dHR, physical significance – the volume of ventilated air per tick of the blood.

Physical working capacity rating is based on the comparison of respiratory minute volume with power (N) when performing a stepwise increasing load on a cycle ergometer, treadmill or stepper, as de-tailed in many works [1, 6, 7, 13, 14], as well on the comparison of respiratory minute volume with heart rate during movements in any chosen sport, including trainings [5]. The breathing mask is given to the subject only for 15-20 seconds at the end of the loading stage or work stage. This makes it possible to re-duce the disruption of natural breathing and not to distort heart rate.

With individual differences in biological responses to loading, the trends at the individual parts of the ventilatory capacity and ventilatory pulse diagrams illustrate the following (see Figure) [3-5]:

1. Stability of the ventilatory capacity and ventilatory pulse rates (5%) under increasing loads – adequacy of aerobic energy supply [12].

2. An increase in the ventilatory capacity and ventilatory pulse rates under high-power loads – the respiratory function provides not only the performance but also the elimination of the resulting oxygen debt, of course, due to the activation of the respiratory function. The ventilatory capacity and ventilatory pulse rates may increase at different speeds depending on the intensity of lactate production and oxidizing capacity of its utilization. It is not always possible to differentiate between the aerobic (AT), anaerobic (AnT), and critical power (Ncrit.) thresholds, since the two closest ones may be within one stage (Fig. 1). But in respect of the pedagogical aspect, it is primarily important to detect an increase in anaerobic glycolysis when performing physical loads. In this case, the steepness of the increase in the ventilatory capacity and ventilatory pulse rates indicates either compensation or predominance of anaerobic glycolysis.

3. A decrease in the ventilatory capacity rates or increase in the ventilatory pulse rates under mod-erate-power loads – neuromuscular fatigue and (or) an irrational movement technique due to excessive pulmonary venation or increased pulse.

4. It should be noted that there are cases, not given in Fig. 1, of a decrease in the ventilatory capacity and ventilatory pulse rates under sub-maximum loads, indicated significant fatigue due to respiratory center depression [9].

In the step test, the illustrations given (except for the fourth one) were detected in terms of two dimensions N1 and N2, which greatly accelerated the testing process (see Figure 1).

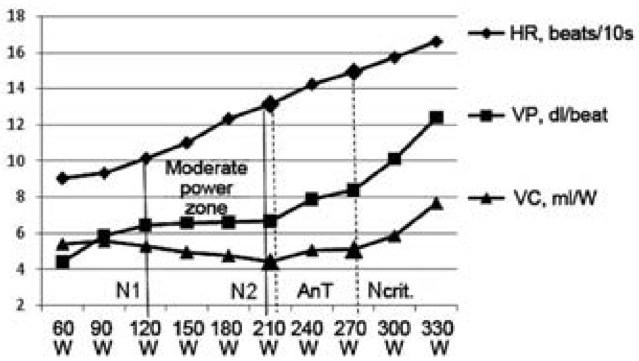

Fig. 1. Cycle ergometer step test with measuring of RMV and HR. Biathlon. HMS A. Sh.

At the same time, it is very important for the training and especially health-improving processes to identify a zone of moderate power characterized by an equal ratio between oxygen demand and oxygen consumption under changing load, which determines the "true stable state" and, consequently, stable working capacity for a long time [10, 11].

Conclusion. Numerous tests (since 2003) of people of different ages and physical fitness levels (from beginners to Olympic champions) have proved that the dynamics of the mentioned ventilatory ca-pacity and ventilatory pulse indicators reflect the level of physical working capacity by demonstrating:

– the presence or absence of neuromuscular fatigue;

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